Cell

Microbial Gardening

For many of us, salicylic acid may conjure up teenage memories of waking up to a huge pimple taking form on our face, just in time for picture day or the school dance. Perhaps fewer of us are aware that like many medicinal compounds, this acne-fighting molecule comes from plants. In fact, salicylic acid is a well-studied plant hormone that plays key roles in a variety of fundamental physiological processes, including growth, stress responses, and perhaps most notably, the plant's innate immune response to microbes. A new study now shows that salicylic acid also plays a key role in shaping the root microbiome (Lebeis et al., 2015).

Like us, plants have a complex relationship with the bacteria in their environment (Sloan and Lebeis, 2015). Exactly how host-microbiome communication is mediated is still unclear, but in animals, the host immune system closely regulates the community of microbes resident in the gut (Belkaid and Hand, 2014). Just as animals are exposed to a variety of bacteria through their guts, where nutrient absorption takes place, plants encounter a huge assortment of soil bacteria through their root systems. However, as is the case for the gut microbiome, only a limited selection of bacteria actually takes up residence in the roots (Lundberg et al., 2012; Bulgarelli et al., 2012).

A recent study from Jeff Dangl and colleagues now shows that plants cultivate the bacteria in their root systems, tending some and weeding out others (Lebeis et al., 2015). By using *Arabidopsis* mutants in which salicylic acid signaling was either disrupted or constitutive, the authors found that the phytohormone altered the bacterial communities colonizing the root. Remarkably, this shift reflected a phylum-level regulation rather than just changes in specific species of bacteria, suggesting that the overall structure of the root microbiotal community is controlled by salicylic acid. In further bacterial colonization experiments analogous to those carried out in germ-free animals, Lebeis et al. reconstructed a synthetic microbial community in sterile seedlings grown in artificial soil and showed that salicylic acid directly inhibits growth of some bacteria but promotes the growth of others. In fact, one type of bacteria carrying salicylate metabolism genes was able to grow on minimal media with salicylic acid as the only carbon source, suggesting that the plant hormone directly feeds its growth.

In addition to providing a potential entry point for improving crop production through microbiome modulation, the study raises broader questions about host-microbiome relationships. The finding that a single molecule can shape the taxonomic structure of the microbiome is intriguing; given that salicylic acid is so crucial for regulating systemic functions in plants, it will be interesting to see whether there will be analogous systemic mechanisms in animals.

Moreover, given that we ingest plants and that diet affects the gut microbiome (Faith et al., 2011), how might this relationship between plant compounds and bacteria play out inside us? Soil bacteria are remarkably effective at colonizing the gut in mice, outcompeting even gut bacteria from other organisms (Seedorf et al., 2014). Do soil-derived bacteria that have evolved to be responsive to plant innate immune hormones reside in our own gut? If so, what happens when we eat plants, thereby introducing the compounds that regulate these bacteria into our bodies? What effects might this interaction in turn have on our own innate immune function and its regulation of the gut microbiome?

***Arabidopsis* plant growing in microbe-rich soil. (image from iStock.com/dra_schwartz).**

It should also be noted that aspirin, which has anti-inflammatory, anti-diabetic, and anti-cancer properties, converts to salicylic acid in the stomach. Although salicylic acid has been shown to activate AMPK, thereby increasing fat oxidation, its anti-diabetic effects are observed even in AMPK mutant mice (Hawley et al., 2012), suggesting an alternate mechanism. Given the effects of salicylic acid on the root microbiome, might some of its health consequences in animals be in part mediated through microbes in the gut? Ultimately, understanding the molecular mechanisms underlying host-microbiota communication will provide the framework for addressing important questions in human health and disease.

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Cindy Lu